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For:	A HIGH-DENSITY DISK RECORDING MEDIUM AND APPARATUS AND METHOD OF REPRODUCING DATA RECORDED TEHREIN		

L E T T E R

Commissioner for Patents
P.O. Box 1450
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February 17, 2005

Sir:

Further to the Amendment filed February 15, 2005, attached hereto is a certified English translation of Korean Priority Document 99-42931 filed October 5, 1999.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37 C.F.R. § 1.16 or under 37 C.F.R. § 1.17; particularly, extension of time fees.

Respectfully submitted,

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DECLARATION

I, Lae Bong PARK,

hereby certify that I am well acquainted with English and that the attached document is a true English translation of Korean Trademark Application No. 10-1999-0042931, completed to the best of my knowledge.

Attachments

1) A certified copy of Korean Trademark Application No. 10-1999-0042931
2) English translation thereof

Signature: Lae Bong PARK

SPECIFICATION

Title

HIGH-DENSITY DISK RECORDING MEDIUM AND APPARATUS AND METHOD OF REPRODUCING DATA RECORDED THEREIN

Brief Description Of The Drawings

FIG.1 is a block diagram of a conventional optical disk device for reproducing data from a disk;

FIG. 2 shows an example of recorded mark or pit pattern and waveforms produced at several points of a conventional disk apparatus when reproducing the pattern;

FIG. 3 is a block diagram of an optical disk device according to the present invention;

FIG. 4 is a detailed block diagram of the multi-level comparator of the apparatus of FIG. 3; and

FIG. 5 shows an example of recorded mark or pit pattern and waveforms produced at several points of the apparatus of FIG. 3 when reproducing the pattern.

Major Elements In Drawings

1: optical disk   2: pickup
3: signal detector   4: comparator
5: phase lock loop   6: bit stream generator
7: demodulator   40: multi-level comparator
41, 42: internal comparator
43: cyclic pulse generator
44: logic circuitry   45: glitch eliminator
46: signal selector

Background Of The Invention

The present invention relates to a disk recording medium such as a compact disk (CD) or a digital versatile disk (DVD) for improving recording efficiency by reducing minimum length

of mark or pit formed by data, and method and apparatus for reproducing data recorded in the high-density disk recording medium.

FIG.1 is a partial block diagram of a conventional optical disk device for reproducing data from a disk. The disk device of FIG.1 comprises an optical pickup 2 for detecting recorded signals from an optical disk 1 such as a CD or a DVD, a signal detector 3 for yielding a reproduced RF signal through adding the signal components detected from the disk 1, a comparator 4 for converting the reproduced RF signal into a binary signal through triggering the RF signal with a reference zero level, a phase lock loop 5 (PLL) for synchronizing an internal reference clock with the binary signal, a bit stream generator 6 for generating a bit stream according to level and its length of the binary signal using the synchronized reference clock, and a demodulator 7 for restoring original digital data from the bit stream through correcting error, if any, with error correction code contained in the bit stream.

The conventional data reproducing operation conducted by the optical device of FIG. 1 is described.

The optical pickup 2 makes a laser beam be incident onto mark or pit trains formed along a track of a recording surface of the disk 1 as shown in FIG. 2, and converts the reflected beam from the beam spot into an electrical signal. The beam reflected from a mark is converted into a low-level electrical signal, whereas the reflected one from a space between marks is converted into a high-level signal.

The components of the converted electrical signal are added in the signal detector 3 and then results in a RF reproduced signal which is applied to the comparator 4. The comparator 4 converts the RF reproduced signal into a binary signal which has only two levels through triggering the RF

signal above and below a reference slicing level, and applies the binary signal to the PLL 5 which synchronizes an internal reference clock with the binary signal in phase. For example, the PLL 5 adjusts the clock speed of a 4.3218MHz internal reference clock to have the falling edge of the internal clock coincided with that of the reproduced binary signal if the disk 1 is a compact disk. Then, the PLL 5 applies the synchronized reference clock and the binary signal to the bit stream generator 6.

The bit stream generator 6 converts the binary signal corresponding to marks and spaces formed in the disk 1 into bit stream referring to the synchronized reference clock, and the demodulator 7 restores the bit stream into original data while correcting the restored data based on the channel correction code contained in the bit stream.

To be brief, electrical signal components detected from a general optical disk by the pickup 2 are added into a reproduced RF signal which is converted into a binary signal after being compared with a reference slicing level, and then is converted into a bit stream based on a reference clock synchronized with the binary signal in phase.

Therefore, the minimum length of a mark or a pit to be formed in an optical disk should be longer than a certain length to be suitable for RF signal conversion and frequency of the reference clock.

In case that an optical disk is a CD for which the reference clock is 4.3218MHz, the minimum and the maximum length of a pit or a space are respectively specified to three pulses, i.e., 3T, which corresponds to 0.86677μ m, and eleven pulses, i.e., 11T, which corresponds to 3.1815μ m, among related companies so that an RF curve produced from the shortest pit formed in the CD might be converted into a bit stream normally.

In the meantime, the related companies are developing a technology to increase the recording capacity of an optical disk. The technology under development is to use a blue laser beam of which wavelength is shorter than that of conventional laser beam, or is to shorten the marginal gap, which is called as 'pitch', between two tracks.

However, since the requirement that a RF curve generated corresponding to a minimum-length mark have enough transition duration should be still satisfied in consideration of RF signal conversion and clock frequency, the shortest mark is not inevitably less than 3T, which puts restriction on increasing recording capacity of a track.

Explanation Of The Invention

It is an object of the present invention to provide apparatus and method of reproducing data recorded in an optical disk, which compares a RF signal reproduced from a disk with multistage reference level and converts bit stream signal corresponding to marks into bit stream, thereby enabling a minimum-length mark or pit to be formed shorter than a conventional minimum-length one.

An optical disk according to the present invention records data in the form of marked phase and unmarked phase such that the length of one or more marked phases or unmarked phases is shorter than a radius of a reproducing beam spot.

An apparatus for reproducing data from an optical disk according to the present invention, comprises a signal detector converting a high-frequency signal reproduced from the disk into a plurality of binary signals through comparing the reproduced signal with two or more slicing levels which are different each other, and outputting one of the plurality of binary signals; and a data converter synchronizing a reference clock with the signal from said signal detector and restoring

the signal from said signal detector into bit stream using the synchronized reference clock, wherein the signal detector includes a plurality of comparators comparing the reproduced RF signal with two or more different slicing levels and outputting different pulse signals, a selector selecting an inputted pulse signal of a certain period T or a certain pulse signal among the outputted signals, and a control signal generator outputting a signal to control the selector after computing the different pulse signals logically, the pulse signal of period T being a signal corresponding to a mark or a space of minimum-length formed on an optical disk, wherein the control signal generator includes a logic element conducting logic computation of level difference signals between the different pulse signals, and a glitch eliminating circuitry selecting level difference signal, whose period is longer than a certain reference, among the signals outputted from the logic element.

A method for reproducing data from an optical disk according to the present invention, comprises a first step converting a high-frequency signal reproduced from the disk into a plurality of binary signals through comparing the reproduced signal with two or more slicing levels which are different each other, and outputting one of the plurality of binary signals; and a second step synchronizing a reference clock with the signal from said signal detector and restoring the outputted signals into bit stream using the synchronized reference clock, wherein the first step includes a first sub-step comparing the reproduced RF signal with two or more different slicing levels and outputting different pulse signals, and a second sub-step computing the different pulse signals logically and selecting an inputted pulse signal of a certain period T or a certain pulse signal among the outputted signals, the pulse signal of period T being a signal

corresponding to a mark or a space of minimum-length formed on an optical disk, wherein the second sub-step outputs one of the plurality of binary signals, if period of level difference between the computed different pulse signals is longer than a certain reference, or the inputted pulse signal if not.

In order that the invention may be fully understood, preferred embodiments thereof will now be described with reference to the accompanying drawings.

FIG. 3 is a block diagram of an optical disk device according to the present invention. The disk device of FIG. 3 comprises an optical pickup 2 for detecting recorded signals from an optical disk 1 such as CD or DVD, a signal detector 3 for yielding a reproduced RF signal through adding the signal components detected from the disk 10, a multi-level comparator 40 for converting the reproduced RF signal into two binary signals through triggering the RF signal with different reference levels 'Vref1' and 'Vref2', a PLL 5 for synchronizing an internal reference clock with the signal from the multi-level comparator 40 in phase, a bit stream generator 6 for generating bit train according to signal state and its length of the signal from the multi-level comparator 40 based on the synchronized reference clock, and a demodulator 7 for restoring original digital data from the bit stream through correcting error, if any, with error correction code contained in the bit stream.

FIG. 4 is a detailed block diagram of the multi-level comparator 40. The multi-level comparator 40 of FIG. 4 comprises a first internal comparator 41 converting the reproduced RF signal into a first binary signal through triggering the RF signal with a reference level 'Vref1' which is above zero level; a second internal comparator 42 converting the reproduced RF signal into a second binary signal through

triggering the RF signal with another reference level 'Vref2' which is below zero level; a cyclic pulse generator 43 generating a periodic pulse signal synchronized with the first binary signal in phase; a signal selector 46 for selecting one to output among the first binary signal and the periodic pulse signal; a logic circuitry 44 outputting a difference signal between the two binary signals through conducting an exclusive-OR operation of the two binary signals; and a glitch eliminator 45 passing pulses of the difference signal from the logic circuitry 44 to a signal selector 46 only when the pulse width is broader than a certain range.

The data reproducing method embodying the present invention conducted by the optical disk device configured as FIGS. 3 and 4 is described in detail with reference to Fig. 5.

The optical pickup 2 makes a laser beam be incident onto mark or pit trains formed along a track of a recording surface of the disk 1 as shown in FIG. 5, and converts the reflected beam from the beam spot into an electrical signal. The beam reflected from a mark or a pit is converted into a low-level electrical signal, whereas the reflected one from a space between marks or pits is converted into a high-level signal.

In the meantime, a minimum-length mark or pit and/or space between mark or pit has been formed in the disk 1 such that its length is shorter than 3T (=0.86677μm), for example, shorter than radius of the reproducing beam, in order to enhance the recording efficiency of a track.

For example, the minimum-length mark has been formed such that its length is 2T (=0.57784μm).

The RF signal reproduced at such-formed minimum-length mark or pit can not be separated far away from a zero level as shown in FIG. 5. The reproduced RF signal containing the monotonously-changing curve which stays around the zero level

is applied to both of the first and second internal comparators 41 and 42 of the multi-level comparator 40.

The first internal comparator 41 compares the applied RF signal with the reference level 'Vref1' and converts it into a binary signal which is, in turn, transmitted to the signal selector 46, the logic circuitry 44, and the cyclic pulse generator 43 which is generating a periodic pulse of which level duration is equal to the length of the 2T mark or pit. The cyclic pulse generator 43 adjusts the speed of the periodic pulse to synchronize the falling edge of the periodic pulse with that of the binary signal, and then applies the synchronized periodic pulse to another input terminal of the signal selector 46.

In the meantime, the second internal comparator 42 compares the applied RF signal with the reference level 'Vref2', converts it into another binary signal, and sends the binary signal to the logic circuitry 44. The logic circuitry 44 conducts an exclusive-OR operation of the two inputted binary signals to obtain a difference signal which has a high pulse at where the levels of the two binary signals are different each other, and transmits the difference signal to the glitch eliminator 45. The glitch eliminator 45 blocks a short pulse, that is, glitch of which duration is shorter than a predetermined time length whereas passing the other long pulse to the signal selector 46.

The signal selector 46 selects and outputs the binary signal from the first internal comparator 41 or the periodic pulse signal from the cyclic pulse generator 43 based on whether the level of the glitch-eliminated difference signal from the glitch eliminator 45 is high or low.

That is, the signal selector 46 outputs the periodic pulse signal, which has short pulse corresponding to 2T mark or pit, from the cyclic pulse generator 43 to the PLL 5 while

the difference signal is in the state of high level.

The PLL 5 synchronizes the reference clock with the periodic pulse signal or the binary signal from the first comparator 41 in phase, and then applies the signal selected at the signal selector 46 to the bit stream generator 6 along with the synchronized reference clock.

The bit stream generator 6 converts the reproduced signal corresponding to marks and spaces formed in the disk 1 into bit stream referring to the synchronized reference clock, and the demodulator 7 restores the bit stream into original data written in the disk 1 while correcting the restored data based on the channel correction code contained in the bit stream.

As explained above, the mark or pit shorter than 3T can be restored to original data normally through the operation of the equipped multi-level comparator 40 comprising two internal comparators 41 and 42 using different slicing levels 'Vref1' and 'Vref2' respectively; a cyclic pulse generator 43 generating a periodic pulse signal whose width is shorter than 3T which is time length of the shortest mark or pit in a conventional art; and a signal selector 46 selecting one from the reproduced binary signal and the periodic pulse signal.

Therefore, the mark or pit can be formed more shortly than conventional art without data loss in reproduction. In the above embodiment, the minimum-length mark/pit and/or space has 2T in time length, however, the minimum-length mark/pit and/or space can be more shorter, for example, 1.5T, than 2T without departing from the technical characteristics explained above.

Effect Of The Invention

The apparatus and method of reproducing data recorded in an optical disk according to the present invention, compares a RF signal reproduced from a disk with multistage reference level and converts bit stream signal corresponding to marks

into bit stream, whereby a minimum-length mark or pit shorter than a conventional minimum-length one can be formed. Consequently, this invention improves the recording capacity of a track formed on an optical disk while ensuring normal reproduction of recorded data.

What is claimed is:

1. A disk recording device recording data in the form of marked phase and unmarked phase, the length of one or more marked phases or unmarked phases being shorter than a radius of a reproducing beam spot.

2. An apparatus for reproducing data from an optical disk, comprising:

a signal detector outputting a pulse signal corresponding to a recorded signal on the optical disk through comparing a reproduced RF signal with two or more slicing levels which are different each other; and

a data converter synchronizing a reference clock with the outputted pulse signal from said signal detector and restoring the pulse signal into bit stream using the synchronized reference clock.

3. The apparatus set forth in claim 2, wherein said signal detector comprises:

a plurality of comparators comparing the reproduced signal with the two or more respective slicing levels and converting the reproduced signal into the plurality of pulse signals according to the respective signal comparison;

a selector selecting one of the plurality of pulse signals or an inputted periodic pulse signal; and

an output controller conducting a logic operation of the plurality of pulse signals and outputting a control signal to control said selector based on result of the logic operation.

4. The apparatus set forth in claim 3, wherein the period

of the periodic pulse signal is corresponding to the minimum length of a marked phase or an unmarked phase formed in the disk.

5. The apparatus set forth in claim 3, wherein said output controller comprises:

a logic circuitry conducting a logic operation of level difference signals between different pulse signals; and

a glitch eliminator passing only a level difference signal, whose duration is longer than a predetermined range, outputted from the logic circuitry.

6. A method for reproducing data recorded in an optical disk, comprising the steps of:

(a) outputting a pulse signal corresponding to a recorded signal on the optical disk through comparing a reproduced RF signal with two or more slicing levels which are different each other; and

(b) restoring the outputted pulse signal into bit stream by synchronizing a reference clock with the pulse signal.

7. The method set forth in claim 6, wherein the period of the periodic pulse signal is corresponding to the minimum length of a marked phase or an unmarked phase formed in the disk.

8. The method set forth in claim 6, wherein said step (a) comprises the steps of:

(a1) comparing the reproduced signal with the two or more respective slicing levels and converting the reproduced signal into the plurality of pulse signals according to the respective signal comparison; and

(a2) conducting a logic operation of the plurality of binary signals and selecting one of the plurality of pulse signals or an inputted periodic pulse signal based on the result from the logic operation.

9. The method set forth in claim 8, wherein said step (a2) selects one of the plurality of pulse signals if duration of level difference between different pulse signals, which the

logic operation is made to, is shorter than a predetermined range.

10. The method set forth in claim 8, wherein said step (a2) selects the inputted periodic pulse signal if duration of level difference between different pulse signals, which the logic operation is made to, is longer than a predetermined range.

ABSTRACT

Summary

The present invention relates to a high-density disk recording medium, and method and apparatus for reproducing data recorded in the medium. The present method comprises the steps of outputting a pulse signal corresponding to a recorded signal on the optical disk through comparing a reproduced RF signal with two or more slicing levels which are different each other; and restoring the outputted pulse signal into bit stream by synchronizing a reference clock with the pulse signal. The present invention is able to form a minimum-length mark or pit shorter than a conventional minimum-length one by comparing a RF signal reproduced from a disk with multistage reference level and then converting bit stream signal corresponding to marks into bit stream. Consequently, this invention improves the recording capacity of a track formed on an optical disk while ensuring normal reproduction of recorded data.

Key Figure

Figure 3

Key Words

Mark length, track direction, multi-level detection, level difference signal, periodic pulse signal

FIG. 1

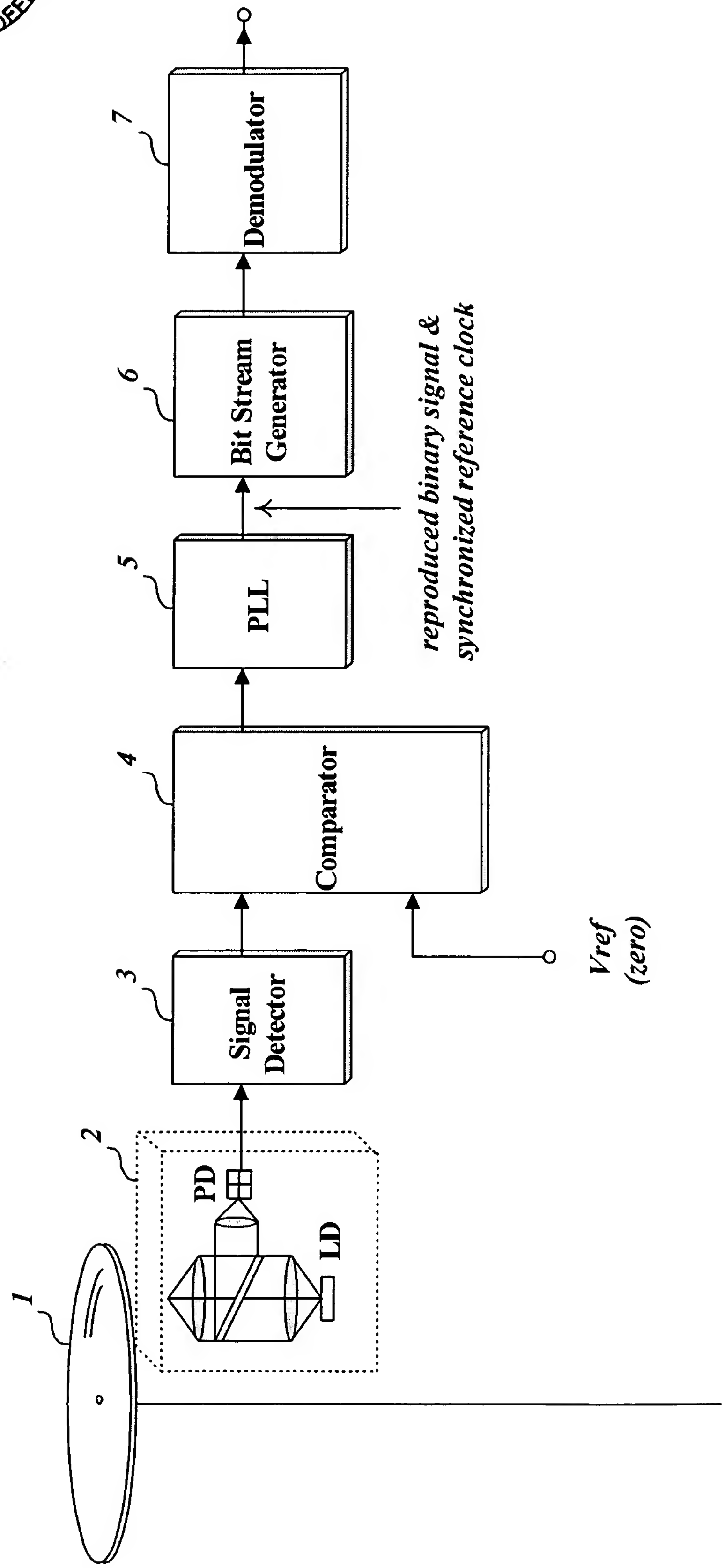

1
2
PD
LD
3
Signal Detector
4
Comparator
Vref (zero)
5
PLL
reproduced binary signal & synchronized reference clock
6
Bit Stream Generator
7
Demodulator

FIG. 2

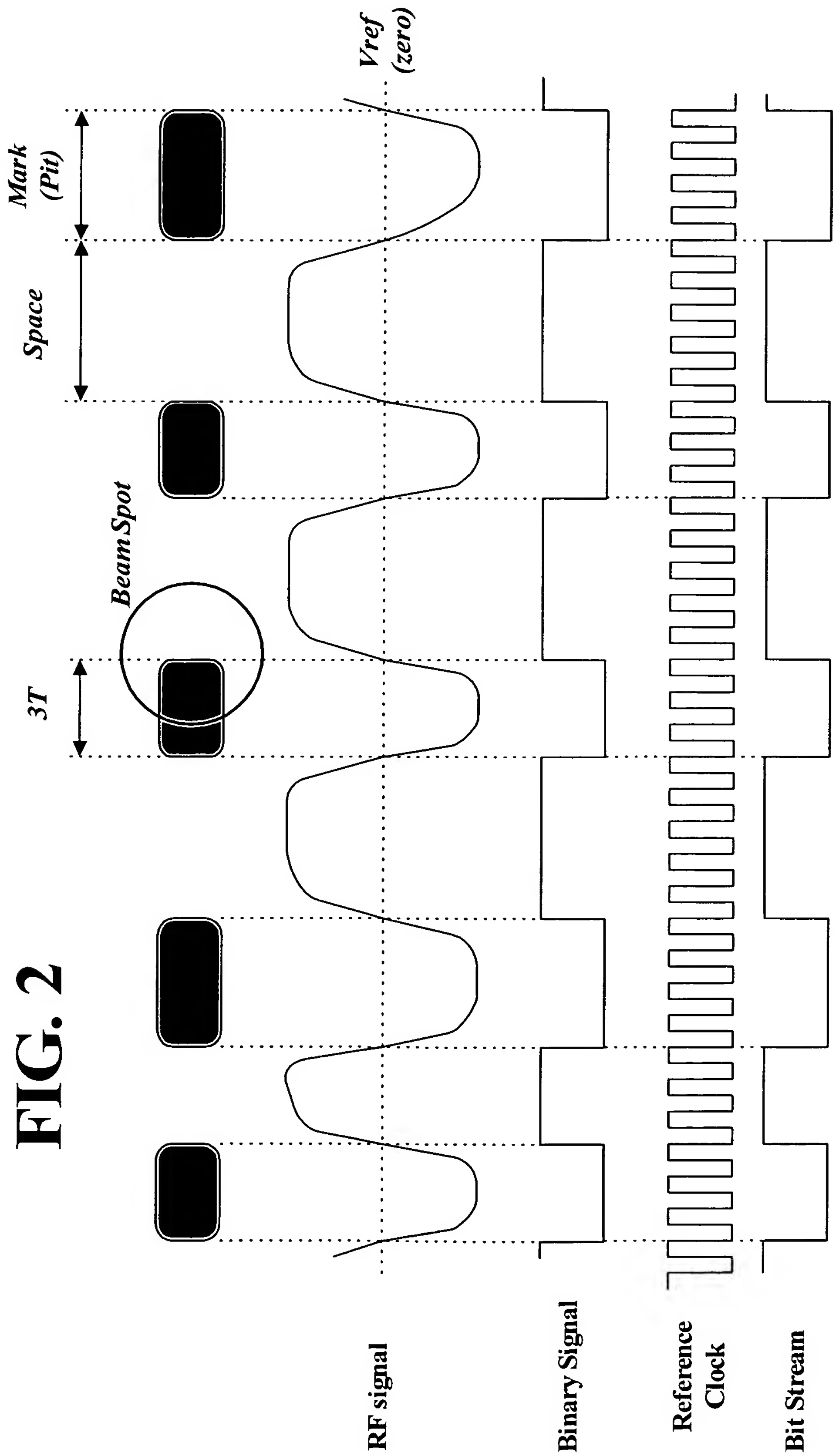

Mark
(Pit)
Space
Beam Spot
3T
Vref
(zero)
RF signal
Binary Signal
Reference
Clock
Bit Stream

FIG. 3

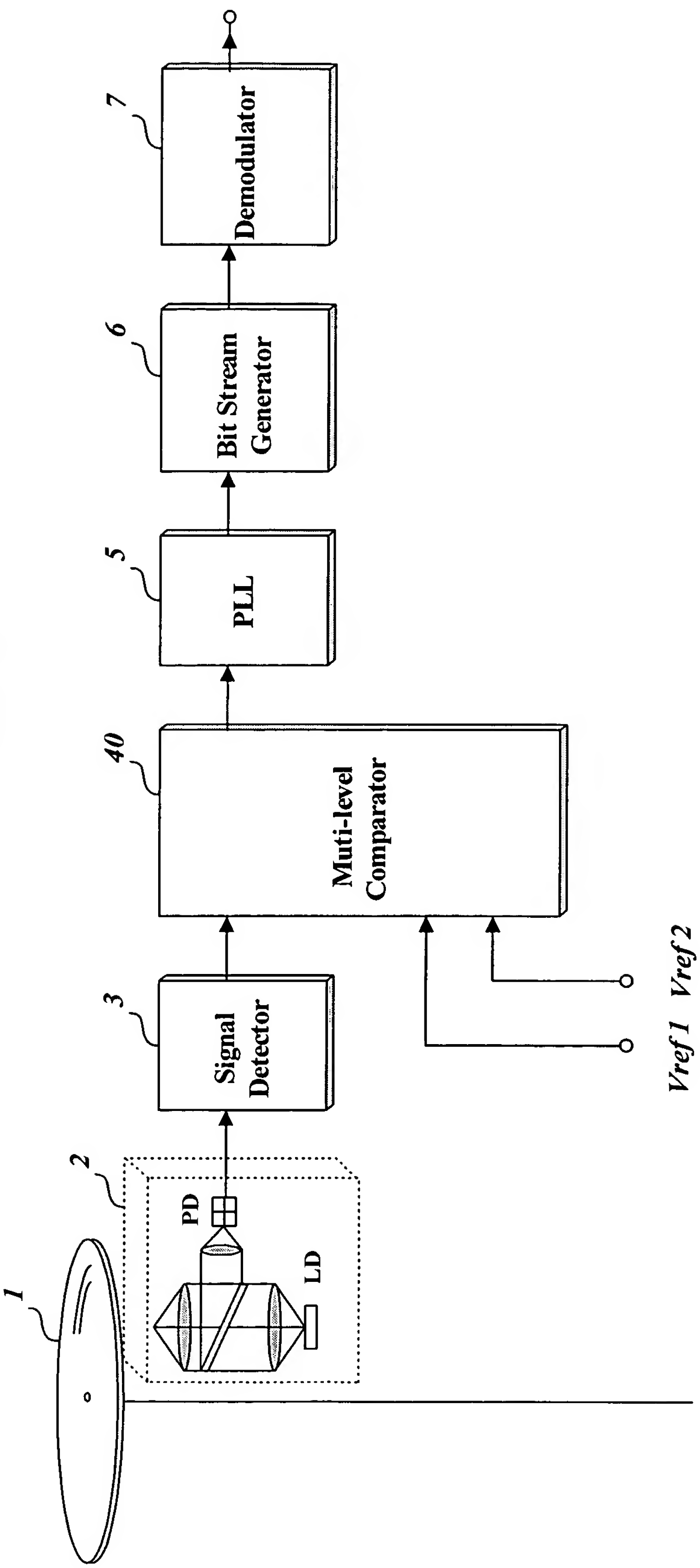
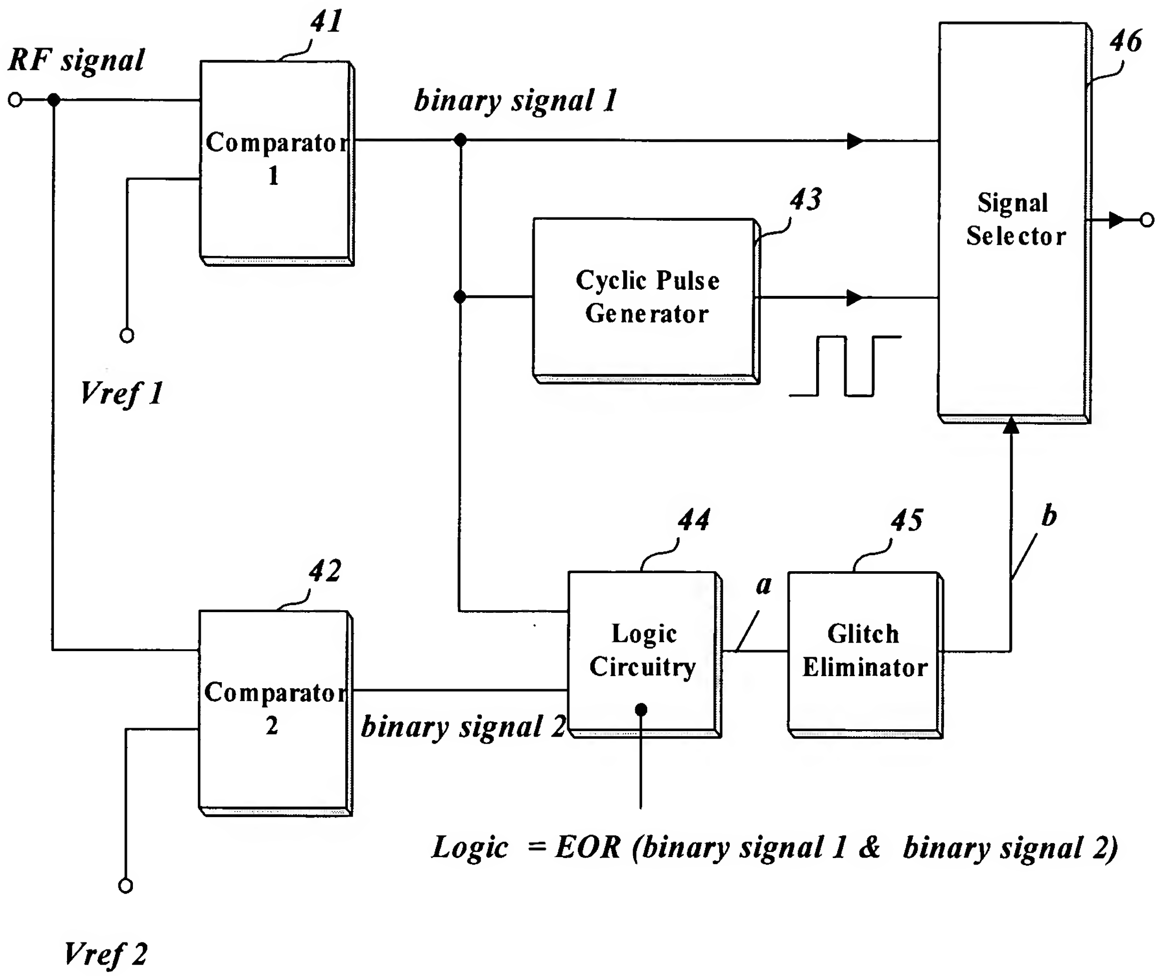
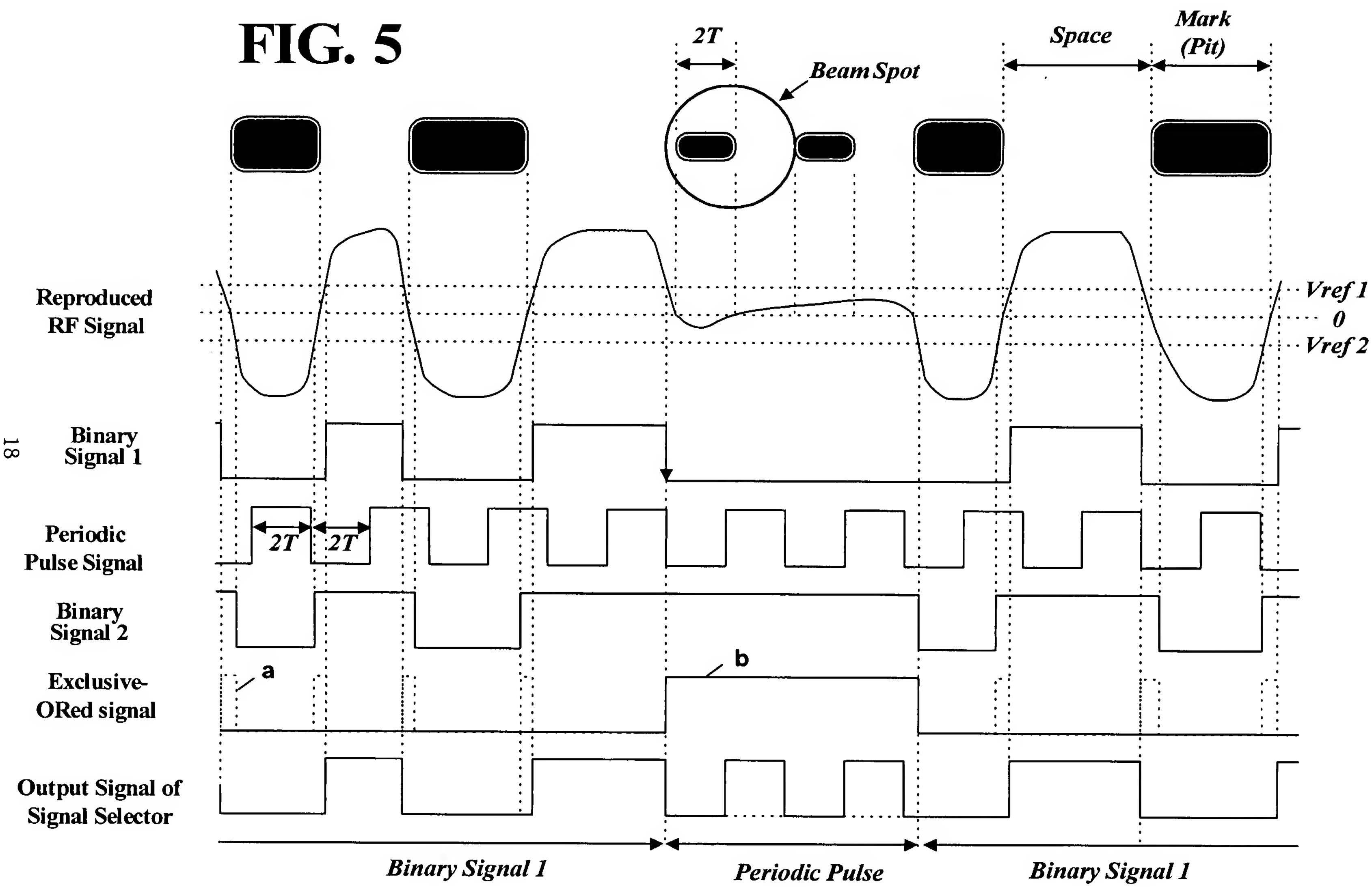

1
2
PD
LD
3
Signal Detector
40
Muti-level Comparator
Vref 1
Vref 2
5
PLL
6
Bit Stream Generator
7
Demodulator

FIG. 4



41
RF signal
Comparator 1
binary signal 1
46
43
Signal Selector
Cyclic Pulse Generator
Vref 1
44
45
b
42
a
Logic Circuitry
Glitch Eliminator
Comparator 2
binary signal 2
Logic = EOR (binary signal 1 & binary signal 2)
Vref 2

FIG. 5


2T
Beam Spot
Space
Mark
(Pit)
Reproduced
RF Signal
Vref 1
0
Vref 2
Binary
Signal 1
Periodic
Pulse Signal
2T
2T
Binary
Signal 2
Exclusive-
ORed signal
a
b
Output Signal of
Signal Selector
Binary Signal 1
Periodic Pulse
Binary Signal 1